

Guggenberger, Tobias; Schellinger, Benjamin; von Wachter, Victor; Urbach, Nils

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Kickstarting blockchain: designing blockchain-based tokens for equity crowdfunding

Tobias Guggenberger^{1,2,3} · Benjamin Schellinger^{1,2,3}  · Victor von Wachter⁴ · Nils Urbach^{1,2,5}

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Abstract

Blockchain-based tokens seek to overcome the friction and opaqueness of the legacy financial infrastructure in the company funding process, particularly in the early-stage and equity crowdfunding domain. While Initial Coin Offerings and Security Token Offerings proposed a solution for crowdfunding, early-stage companies still face challenges in using blockchain as an alternative equity funding infrastructure. In this context, the idea of blockchain-based equity tokens remains hypothetical. In addition, the literature lacks design theory for the development and implementation of blockchain-based equity tokens. This research bridges this gap by designing, developing, and evaluating an equity token prototype for crowdfunding, following the design science research approach. We propose a refined crowdfunding model and derive seven design principles that contribute to the design theory of equity tokens. The research results show that blockchain-based equity tokens improve efficiency, transparency, and interoperability while meeting regulatory requirements and facilitating secondary market trading.

Keywords Blockchain · Design science · Equity crowdfunding · Initial coin offering · Security token offering · Tokens

1 Introduction

Entrepreneurship is a desirable goal for economies to foster innovation, stimulate economic growth and create employment [1–3]. During the early stages of entrepreneurship, funding is often indispensable to drive forward and implement an idea or a project. Therefore, funding as a method of raising capital outside of operating cash flow is of utmost importance to mitigate early-stage companies' operational risks and secure long-term growth. However, entrepreneurs still face various problems

✉ Benjamin Schellinger
benjamin.schellinger@fit.fraunhofer.de

Extended author information available on the last page of the article

during and upon a traditional early-stage funding process, including geographical constraints, exclusive networks, and the involvement of multiple intermediaries [1, 4, 5]. In addition, it is slow and expensive owing to the plethora of intermediaries involved [4, 6, 7].

In an endeavor to improve early-stage funding, equity crowdfunding emerged as an alternative funding tool, reaching a total funding amount of over \$1.5bn globally in 2018 [8]. Equity crowdfunding is a crowd-based form of issuing company shares in exchange for capital via an Internet platform giving investors equity-like rights. These rights make equity crowdfunding more similar to the issuance of shares than they mimic the idea of donation- or reward-based crowdfunding [9–11]. Although equity crowdfunding optimizes prior forms of early-stage funding, it lacks broad liquidity, entails bureaucracy and high administrative costs while still relying on trusted intermediaries, such as centralized platform providers [12–14].

Initial Coin Offering (ICO) via blockchain technology proposed an alternative approach to traditional crowdfunding and enabled more efficient crowdfunding processes, thus, democratizing early-stage investments [6, 9]. In an ICO, investors generally trade in their cryptocurrency in exchange for a utility token, representing the right to use a particular offered service [15, 16]. Following substantial growth in 2017 (\$6.2 bn) and 2018 (\$7.8 bn), total funds raised through ICOs decreased to \$0.3 bn in 2019 [17]. Consequently, initial enthusiasm has turned into declining investment in ICOs, mainly because of unclear regulation, limited configurability, and insufficient investor protection [18].

The stagnant technological improvement of the traditional funding process and the lack of regulatory compliance of ICOs led to the latest development of Security Token Offering (STO). A security token is a digital representation of particular security issued and managed on a blockchain using smart contracts and computer code that executes arbitrary business logic [16, 19]. Unlike utility tokens, security tokens issued via STOs comply with regulatory requirements by default, grant the token holder an underlying value, and, eventually, present a more matured form of token sales [20–22]. As such, STOs can be seen as an alternative to equity crowdfunding platforms. Thus, we state that blockchain technology improves the efficiency, transparency, and interoperability of conventional equity crowdfunding. In addition, the configurability of smart contracts allows regulatory compliance and creates liquidity, facilitating trading in the secondary market.

Even though researchers recognize the value of blockchain for equity crowdfunding, theory in this area is limited [23]. In summary, existing research [9, 12, 24] focuses on the potentials of blockchain for equity crowdfunding but lacks design knowledge in this context. However, design theory is a prerequisite to understanding how such systems should be implemented and effectively foster added value [25, 26]. To address this gap, we define the following research questions:

RQ: How can blockchain be incorporated as an alternative infrastructure for equity crowdfunding?

Our research objective is to bridge the identified gap in the IS literature and answer the question by designing, implementing, and evaluating a blockchain-based equity token prototype following the design science research (DSR) paradigm [27–29]. In doing so, we aim to respond to Treiblmaier et al. [30] call to design a

security token and explore its potential to reduce information asymmetries, improve operations, and ultimately allocate capital more efficiently. In addition, we take up the research agenda by Kranz et al. [22] and the call of Perdana et al. [31] and focus on a particular security token, i.e., an equity token. This paper is the first to design a blockchain-based equity token for crowdfunding to the best of our knowledge.

Overall, we seek to make the following primary contributions. First, developing a blockchain prototype will allow us to gain practical insights into the opportunities and challenges of implementing complex blockchain-based solutions, expanding the blockchain-based equity token research and the early-stage funding fields. Second, we seek to deepen the understanding of mandatory requirements and the infinite design space of blockchain-based equity tokens, contributing to design theory in this field by developing and evaluating an instantiation of a blockchain-based equity token for crowdfunding. Third, we extend the crowdfunding model developed by Haas et al. [32] by outsourcing traditional financial and operational services to smart contracts and adding new stakeholders. Fourth, we seek to derive seven generalized design principles (DP) to guide the design and development of blockchain-based equity tokens.

The remainder of this paper is structured as follows: In Sect. 2, we present the principles of traditional early-stage funding and equity crowdfunding, followed by blockchain-based crowdfunding. Next, in Sect. 3, we present our DSR approach, while in Sect. 4, we elaborate on the instance problem, i.e., equity crowdfunding. Section 5 shows the derived software requirements and provides a detailed account of the software prototype development. In Sect. 6, we evaluate the prototype and the research approach. Section 7 generalizes and discusses the results based on both the literature and semi-structured interviews and derives design principles. We conclude with a summary, highlighting limitations and outlining future research directions in Sect. 8.

2 Background

2.1 Early-stage funding and equity crowdfunding

2.1.1 Early-stage funding

Entrepreneurship is a pursuable goal in every economy as literature has long identified the role of entrepreneurship in enhancing innovation, economic growth, and job creation [1–3]. When looking to thrive an idea or project, early-stage entrepreneurial funding is often inevitable. However, due to the short business history, funding instruments like loans or bonds provided by financial institutions or other market participants are not available [7, 33]. Thus, the financing of early-stage companies takes place in the private market through the issuance of large investment tickets, which excludes small investors from participating in these companies. Consequently, this led to establishing an inaccessible and concentrated market for early-stage funding with specialized participants [34]. In particular, specialized intermediaries,

which are reputed to be experienced with high uncertainty and principal-agent problems to entrepreneurial financing, serve the market [7, 35].

In this context, the US-style venture capital process has been subject to criticism ever since and is regarded as one of the major constraints for full exploitation of the economic potential of entrepreneurship [1, 4, 5]. The process of entrepreneurial funding takes a substantial amount of time, involves many different parties, leads to cumbersome bureaucracy regarding the preparation of contracts, requires sound knowledge and a personal network in the industry. In addition, it is slow and expensive owing to the plethora of intermediaries involved [4, 6, 7, 36]. Consequently, this stagnant funding process led entrepreneurs to look for ways to improve the traditional venture capital funding system [65].

2.1.2 Equity crowdfunding

Equity crowdfunding platforms are a promising improvement heavily discussed in the literature [10, 11]. Equity crowdfunding is a crowd-based form of issuing company shares in exchange for capital via an internet platform [11]. Websites usually host these platforms, while web-based software often facilitates interaction between entrepreneurs and investors willing to fund their projects [33]. While in the traditional system, money is provided towards selected projects, crowdfunding can be accessed by a larger group that decides to invest a smaller contribution into a potentially successful company [36]. For example, EquityNet offers companies a platform to promote their venture, including business cases and financial figures. The investment in a company is a stark contrast to well-known fundraising platforms like Kickstarter and GoFundMe, which are raising money for a project without expectation of return (i.e., they are in contrast donation-based or reward-based for non-monetary rewards) [9, 10]. Both conventional and equity crowdfunding share common characteristics: Early and global access via an Internet platform makes it possible to gather a contributing community around the company from the very beginning. Therefore, these crowdfunding mechanisms facilitate the attraction of investors, create a brand, and increase media coverage [9, 33]. Yet, crowd interest is often more diverse and involves social intent [33], and crowdfunding investments are spread across a broader range of companies than traditional venture capital. But whereas Kickstarter has revolutionized the fundraising space for reward-based projects, the adoption of equity crowdfunding platforms is still limited [15].

In summary, our literature analysis reveals that there is no overall satisfying funding mechanism to answer the specific needs for early-stage companies in a fast, affordable, and equal manner. Thus, we explore a novel blockchain-based funding mechanism that tries to address the shortfalls to bring equal benefits to entrepreneurs and investors.

2.2 Blockchain-based crowdfunding

2.2.1 Blockchain

The interest of academia and practice in blockchain technology first arose after the Bitcoin white paper by Nakamoto [37], who proposed a peer-to-peer (P2P) digital currency. Many researchers and practitioners state that blockchain can radically change an extensive range of business processes [25, 38, 39]. *Blockchain* describes a distributed ledger that records and secures transactions in a decentralized network [25]. A trust-free consensus algorithm, run by the participating nodes, determines the order of all executed transactions and the currently valid blockchain state [40].¹ In addition, blockchain describes an algorithmic protocol with the potential for global disintermediation through the decentralization of transaction confirmation between participants who previously did not trust one another [41].

With its decentralized application platform, using a virtual machine (EVM) and a built-in Turing-complete programming language, the Ethereum blockchain facilitates the use of smart contracts [42]. *Smart contracts* describe an algorithmic transaction protocol that automatically executes the terms of a contract on a blockchain to achieve trust between two or more unacquainted participants [43]. The consensus protocol ensures the enforcement of these scripts and can reduce transaction costs and improve settlement speed [26, 40, 43].

2.2.2 Blockchain tokens and distribution

A token is a series of characters that identifies a specific asset right or asset class [44]. Technically tokens can be used in several cases, e.g., an internal unit of account, facilitation of transactions, or to grant token holders certain types of privileged access [42, 45]. While a native token is deeply implemented on the blockchain protocol (e.g., Bitcoin or Ether), tokens issued on top of the blockchain layer are usually managed by smart contracts [16, 46]. Since the Ethereum blockchain was the first to allow for implementing business logic using smart contracts, different standards of the token interface have emerged over the years to ensure interoperability on the platform. The Ethereum community, developer, and token holders can propose improvements (EIP, Ethereum Improvement Proposals) on smart contract functionalities, resulting in the relevant Ethereum Request for Comments (ERC), such as ERC20, ERC721, ERC1155, and EIP1400 (see Table 1).

Chiefly, tokens can be divided into utility and security tokens. Utility tokens are issued via Initial Coin Offerings (ICOs) and provide access or payment to digital services, granting the issuing company complete control about which rights and claims are connected to the token [15, 16]. The literature confirms the benefits of ICOs as a funding alternative over traditional crowdfunding methods [45, 47] and extensively analyzes its success factors [48–51].

¹ A consensus algorithm is only purely considered trust-free if it does not rely on trusted validating nodes, e.g., in the context of a private blockchain.

Table 1 ERC Token Standards on the Ethereum Blockchain

| Token type | Fungible | Non-fungible | Multiple | Security-token |
|-----------------|---|--|--|------------------------|
| Characteristics | Divisible | Unique | Divisible and unique | Regulatorily compliant |
| Use cases | Currencies, access or vot- ing rights | Collectibles, tickets, digital artwork | Equity, real estate, in- game items | Financial securities |

However, ICO tokens also have drawbacks that negatively affect the use of the platform. Although the flexibility can explain the previous dominance of utility tokens, the issuing company, regulatory loopholes, a broad investing community, and the efficiency of blockchain [52], the majority of ICOs may have been misguided or even fraudulent with no intention of fulfilling the project pipeline [53]. Concerns have been raised about the lack of regulatory compliance and basic investor protections, as ICO tokens are considered securities in disguise, owing to the reward-based character [18]. In addition, there is a lack in incorporating real-world security regulation on the blockchain and supervising mechanisms steering the company [54]. Consequently, ICO success is bound to the attractiveness of the underlying value, e.g., the company and the granted token rights. However, often the token issued does not inhibit rights and thus has no underlying value.

Recently, the advancement of ICOs to security token offerings (STOs) holds new promises for token-based funding [21]. Unlike ICOs, STOs cater for the whole funding lifecycle, i.e., issuance, maintenance, dissolution, regular communication (e.g., quarterly reporting), voting rights, and equity-specific transactions (e.g., dividends). In addition, STOs apply to cross-border regulation with on-chain and off-chain interactions by design using programmable smart contracts and hence present a more matured form of token sales [20, 22]. Security tokens represent tokenized ownership, i.e., a digital representation thereof, and are subject to security regulation [16, 19]. Equity tokens are a subclass of security tokens and represent ownership of equity that entails rights and obligations under equity legislation, e.g., right to dividends or voting rights. Thus, equity tokens are digital representations of shares on a blockchain [16]. On the other hand, a vast number of decentralized finance (DeFi) projects, such as Uniswap, Aave, or Curve, primarily emulate ownership by issuing governance tokens. However, these governance tokens only grant utility token-like rights to these DeFi protocols, i.e., voting rights in project development, and thus do not represent a regulated form of a security, or more specifically, an equity token for these projects [55].

Both utility and security tokens are fungible and tradable, but their value is derived differently from the underlying asset or service they represent [19]. Due to the infinite design options and legal complexity, it is not easy to classify tokens, and in fact, many tokens are between the categories of utility and security. If a token is either a utility or security is commonly tested by a legal precedent determining security status. In this context, the Security Exchange Commission (SEC) in the U.S. has developed the Howey test to assess whether a token can be classified as a security and thus needs to be regulated. The SEC Howey Test has evolved as a de facto

simplifying standard within the blockchain community once a token is considered a security. According to the test, a token will be classified as security if all four of the following requirements are fulfilled: (i) investment of money, (ii) common enterprise, (iii) profit expectation, and (iv) solely on the effort of others. The legal status of utility tokens is surrounded by controversy due to the grey area of their true economic value. Accordingly, regulation across the globe has been different, ranging from pending regulation to promotion on a case-by-case evaluation to outright ban [53]. Security tokens go along with a more expensive initial registration, more obligations to investors during the lifecycle of the security, and potential fines if investor rights are not met [52]. In what follows, we take the U.S. law as our starting point and therefore cannot ensure that it applies to early-stage companies in other jurisdictions.

An early-stage company could circumvent traditional equity funding vehicles like venture capital or private equity by issuing equity tokens through blockchain. The token issuance process purely relies on P2P mechanisms instead of the match-making process by crowdfunding platforms and banks between campaign creators and potential investors [32, 56]. Unlike conventional crowdfunding, token sales offer common advantages that make it more attractive to global investors. There is a deeper pool of liquidity, and ownership becomes divisible and thus tradable [57]. Companies can develop their proprietary blockchain protocol to issue and sell native tokens [45] or use existing infrastructure, e.g., the Ethereum blockchain, and sell on-chain utility tokens [48, 57].

Even though researchers recognize the merits of token sales, the literature on blockchain-based crowdfunding is limited. Arifin et al. [24] propose that blockchain-based crowdfunding can lever financial inclusion and reduce challenges associated with platform operators. Zhu and Zhou [12] analyze blockchain-based equity crowdfunding in China and find that blockchain can reduce frictions, thus facilitating the circulation of equity shares. In addition, blockchain enables P2P transactions, improves governance, and provides regulators with necessary market information [12]. In a Delphi Study, Heieck [9] confirmed driving the merits of blockchain-based equity crowdfunding. They find that specific driving forces positively (e.g., costs from equity funding) and negatively (e.g., asymmetric information) affect equity funding. While Hartmann et al. [23] reveal success factors for conventional and blockchain-based crowdfunding and propose future research in this area, Stekli and Cali [58] show that equity crowdfunding via blockchain facilitates the financing of clean energy projects.

Overall, blockchain technology has given entrepreneurs the capability of creating and issuing tokens for fundraising. Regulatory compliant security tokens, including equity tokens, reduce the trust barrier that ICOs and traditional equity crowdfunding struggled with. However, equity tokens are nascent and must be designed correctly to comply with laws and regulations, ultimately reshaping the landscape of funding, entrepreneurship, and innovation [56, 59].

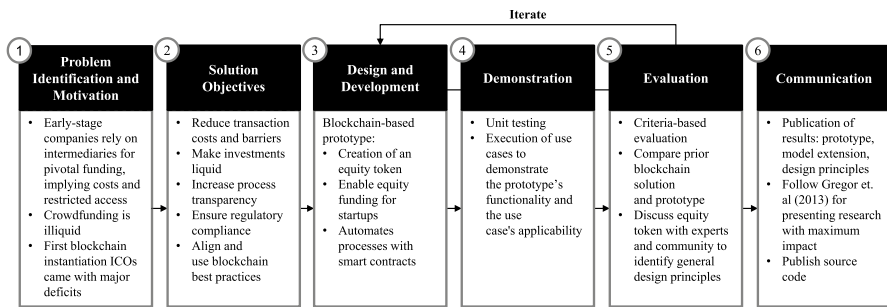


Fig. 1 Research process (adapted from Peffers et al. [61])

3 Method

To develop an equity token, we followed the DSR approach [28, 29, 60]. DSR generally seeks to solve an identified problem in a build-and-evaluate process that ultimately produces purposeful design artifacts [28]. Further, DSR's output can be constructs, models, methods, and instantiations, while a prototype is a typical instantiation [29]. In the end, the derived knowledge should be generalizable and, therefore, applicable to similar settings. To achieve this, we drew on both the early-stage funding and the blockchain literature when developing our blockchain prototype, deriving generalizable knowledge in a two-step evaluation. We addressed the shortfalls of the crowdfunding process and ICOs by developing and evaluating an instantiation of a blockchain-based equity token. We applied Peffers et al. 's [61] widely accepted research approach to structure our research (see Fig. 1). We iteratively used the design and development, demonstration, and evaluation steps [60, 61].

The following steps guide this research: Our research is motivated by a lack of knowledge on the design of equity tokens and their applicability. We identified traditional early-stage funding as a practically relevant problem that blockchain technology could improve [5, 7, 12–14]. We analyzed traditional equity crowdfunding problem areas and the first wave of blockchain-based solutions, i.e., ICOs. Major problems in the traditional equity crowdfunding domain include the credibility of crowdfunding platforms, a lack of secondary market trading, and high administration costs [12–14]. In contrast, ICOs pose great challenges, including missing underlying value, the need to comply with current regulations, and allowing for higher interventions [52, 54]. To address the identified challenges, we use both the areas for improvement of equity crowdfunding (EC-AFI) and ICOs (ICO-AFI) to derive design objectives (DOs) that an improved solution must fulfill.

Furthermore, we built our derivation of DOs on the literature on equity crowdfunding and blockchain technology and the examination of past ICOs. Accordingly, we elaborate on 14 DOs for the software prototype design, implementation, and evaluation. The DOs were a starting point for the development stage. As is standard in software development, we defined the required data types and the intended solution methods. Based on the defined DOs, we implemented our equity token with

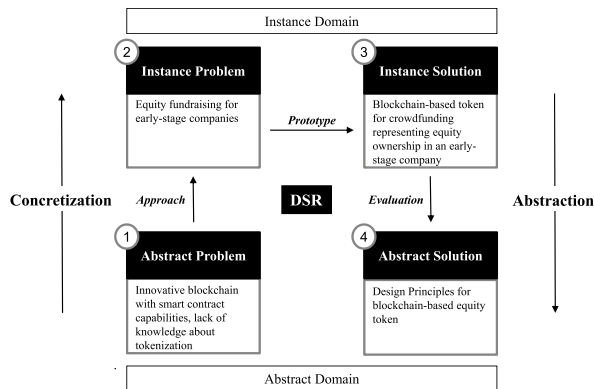


Fig. 2 Design science research: concretization and abstraction

additional emission and transaction protocols. We developed the prototype in an Ethereum environment since it is considered a matured platform for smart contract development [62]. Finally, we conducted seven semi-structured expert interviews. This procedure allowed us to get feedback from experts on our reference implementation and the application of blockchain technology for equity tokens, which was fundamental to generalize from an instance solution to an abstract solution (see Fig. 2).

4 Problem identification and design objectives

Limitations in the early-stage funding process are regarded as one major constraint for better exploitation of the economic potential of entrepreneurship [1, 4, 5]. In the background section, we point out several problems for early-stage equity funding raised in the equity crowdfunding literature. We argue that blockchain technology—a technology that enables trust among participants and automates business logic [40]—has the potential to address the raised deficits. ICOs promise to offer a blockchain-based alternative for crowdfunding but do not use the tokenization of equity.

As the funding mechanisms show potential for improvement, we derive several AfIs from the relevant literature (see Table 2). To ensure a practical improvement compared to conventional funding, we enrich the shortfalls derived in the literature with case-specific insights from real-world funding. In particular, one of the authors conducted a conventional funding process over twelve months as the leading manager in a startup. Please note that we follow U.S. regulations when considering compliance.

Based on the identified AfIs of equity crowdfunding and ICOs, we followed an iterative cycle of deriving DOs. Thus, a DO addresses one or multiple issues (AfIs) raised in the application domain. We discussed possible DOs internally and with other researchers and finally aggregated 14 DOs for our approach, which directly informs the prototype development like software requirements. For each DO

Table 2 Areas for Improvement

| Dimension | Area for improvement | Description of the status quo |
|------------|--|---|
| Trust | EC-Aff01: Credibility of crowdfunding platforms | Shares of a crowdfunding company are not registered at a credible registry or traded on a reliable settlement system like public stock exchange systems. Equity crowdfunding instead relies on centralized organizations that typically have lower levels of regulation than the conventional stock market. Hence, equity crowdfunding registration and management are less secure, jeopardizing investment capital [12] |
| | EC-Aff02: Missing secondary market | In equity-based crowdfunding, investors only have limited exit options, e.g., share buyback schemes, trade sales, or sales on the stock market after an initial public offering. In traditional stock markets, investors can sell their assets through secondary markets to other investors [70], often lacking in equity crowdfunding [71]. Thus, investors face much higher lock-in effects, limiting effective equity circulation and ultimately discouraging potential investors [12, 14] |
| Costs | EC-Aff03: High administration/ transaction costs | The administrative processes in crowdfunding are generally based on paper documents, e.g., for registering shareholders. As investors are usually distributed regionally, there is a strong reliance on signatures and postal mail to exchange the relevant documents. Such processes are time-consuming and correspondingly expensive [13, 70] |
| Valuation | ICO-Aff01: Price discovery | It is hard to price the inner value of utility tokens, resulting in high volatility and speculation. Reasons for problematic pricing include the lack of underlying value, the uncertainty of the final service or product, and the often capped, one-time token distribution [15, 75, 76] |
| Compliance | ICO-Aff02: Not compliant with current regulations | Utility tokens do not have standard investor protections, including the ability to track ownership and identity. However, professional investors generally demand these properties [54]. In addition, existing ICOs and their token architecture on the Ethereum platform offer no built-in mechanisms for regulatory enforcement, e.g., Know-Your-Customer (KYC), Anti-Money-Laundering (AML), or token-level restrictions [77]. Although certain ICOs implemented legitimation processes, there was a lack of built-in regulation for selling these tokens to other unverified market participants [52] |
| | ICO-Aff03: Incompatible with higher interventions | There is a lack of operating tokens by third parties. There are several arguments for higher interventions: lost keys, unauthorized ownership, fraud, or crime—requiring access by third parties [48] |
| | ICO-Aff04: No reporting standards | ICO projects are often subject to an openly accessible crowd due diligence before token issuance, helping auditors retrieve transaction data early on [59, 73]. However, there is no requirement to broadcast the company's performance upon successful funding, e.g., through quarterly financial statements, KPIs, or ad hoc messages [54]. Therefore, a multitude of ICOs does not include reporting standards |

Table 2 (continued)

| Dimension | Area for improvement | Description of the status quo |
|------------|---|--|
| Governance | ICO-Aff05: Conflict with the entrepreneurial funding cycle | Traditionally, early-stage funding comes with a system of checks and balances to align the interests of investors and companies. In contrast, ICOs are the only funding event, with tokens often capped to realize maximum returns [15]. Thus, this model incentivizes founders to raise too much money too early, presumably leading to a waste of resources [78] |
| Technology | ICO-Aff06: Inflexible architecture | ICOs lack upgradability. This inflexibility in smart contract design leads to vulnerabilities. Creating future-proof smart contracts will require the ability to easily upgrade for vulnerabilities [79] |
| | ICO-Aff07: Limited configurability | The characteristics of an investment contract for early-stage equity are manifold, owing to the variety of business models, team compositions, and different environments. ICOs—and utility tokens—offer minimal design options |
| | ICO-Aff08: Risks in the code | The security of blockchain-based applications depends not only on the base layer but also on the smart contract. Largely, ICOs did not follow audited token standards beyond ERC20 as they were not in place [80]. Equity tokens could implement country-specific regulatory standards, which once audited enforce transaction regulations and be shared openly |

evaluation, we defined criteria to evaluate the goodness of the prototype, an essential requirement for rigor DSR research (see Table 3).

5 Design and development

5.1 Prototype design and architecture

We implemented the prototype utilizing the public and permissionless Ethereum blockchain [42]. A set of Ethereum smart contracts represent the necessary business logic. Further, we used the InterPlanetary File System (IPFS) as distributed storage technology (IPFS 2020) to facilitate effective document-sharing (necessary for KYC/AML).

Figure 3 illustrates the building blocks of the blockchain-based equity crowdfunding service ecosystem as a class diagram. We emphasize a core token smart contract, handling critical functionality such as transactions and accounting. Additionally, we deployed app-like smart contracts addressing the needs of different agents (issuing company, attorney, investor), such as know your customer (KYC) and equity prospectus.

As seen in Fig. 3, the core equity token implements basic functions for transferring tokens, obtaining account balances, getting the total supply of tokens, and allowing approvals. Notably, the token standard informs the core token, including the authorization layer of specific actions (*modifier*) [63]. Each token is implemented and deployed in a separate smart contract. This practice is common in smart contract design [64] and has several implications. Primarily, it ensures the security aspect that each funding is independent of another—a loss of access to one smart contract would not affect another. Companies can issue multiple token types over time, each with different characteristics for investors (e.g., class A or B shares), thereby addressing different investor groups. The token type is traceable by a unique identification number and is defined by pivotal metadata such as *totalAmount* and *categoryShare*, or to which *companyOwner* the token belongs. Further, a company can increase or reduce the number of previously issued tokens by issuing or burning them.

The architecture ensures backward compatibility with Ethereum token standards, such as ERC20 and relatively new proposals such as EIP1400 and EIP1410 [65]. This compatibility is essential if one is to interoperate with other implementations on Ethereum. The backward compatibility can be turned on and off if new standards emerge. Once the smart contracts are deployed on the Ethereum blockchain, it assigns addresses that make the smart contracts publicly accessible [66]. Multiple parties can then use the prototype. Only the contracts' addresses and knowledge of the public core functionalities are required to interact with the prototype. Section 6.2. describes the token issuance and token transaction in detail.

To ease the interaction with the equity token we deployed app-like smart contracts for each party. For example, the issuing company can provide necessary documents supporting the equity issuance. The documents are uploaded on IPFS and linked to a transaction on the blockchain. Furthermore, the investor can provide

Table 3 The Design Objectives

| Dimension | Design objective | Description | Evaluation criteria | Addressed Afl |
|----------------|--|---|--|--|
| Business Logic | DO01: Define and enforce specific characteristics of equity | The prototype should include the key characteristics of equity regarding the entire lifecycle, e.g., issuance, maintenance, dissolver, regular communication (e.g., quarterly reporting), voting rights, and equity-specific transactions (e.g., dividends) | Implementation and enforcement | ICO-Afl01 ICO-Afl02 ICO-Afl04 ICO-Afl05 |
| Compliance | DO02: Define and enforce regulatory requirements | The prototype must comply with current regulatory requirements. In particular, it must implement personal identification processes (KYC/AML) and token-level restrictions. These restrictions consist of pre-transaction checks for authorized and accredited investors and require the implementation of nonfungible tokens | Implementation and enforcement | ICO-Afl01 ICO-Afl02 |
| Technology | DO03: Provide global access to all investor types | The prototype should technically allow for small investments without regional censorship or discrimination since it is crucial to democratize investments into startups, thereby enabling funding [1] | Possible number of min. investment and fulfillment | Key requirement EC-Afl02 |
| Compliance | DO04: Provide a framework to hamper fraud via crowd due diligence | Investors perform time and resource-consuming due diligence to assess an early-stage company's potential value owing to the large investment size. Blockchain technology allows for fragmented investments, leading to a decrease in the average investment ticket. Since this development could reduce due diligence efforts [1], the solution must allow for a uniform structured discussion and review of a venture for participants | Implementation and enforcement | EC-Afl01 ICO-Afl04 |

Table 3 (continued)

| Dimension | Design objective | Description | Evaluation criteria | Addressed Afl |
|------------|---|--|---|---|
| Technology | DO05: Store and process data transparently, immutably, and permanently | Data should be as transparent as possible to improve audits. Nonetheless, regulatory and data privacy considerations set reasonable boundaries for transparency. Further, to avoid malicious changes in related data, the prototype must also process transactions in a tamper-proof way and store data persistently and immutably | Fulfillment, transparency, and trust mechanisms | Key requirement EC-Afl01 ICO-Afl02 ICO-Afl04 |
| Technology | DO06: Reduce manual activities | The manual activities involved during the issuance and management of the equity lifecycle should be automated to reduce costs and the possibilities of fraud | Manual activities | Key requirement EC-Afl03 |
| Technology | DO07: Sufficient transactions | In an improved solution, the number of transactions should be manageable without constraints | Throughput rates | Key requirement EC-Afl02 |
| Governance | DO08: Allow process interactions | Blockchain technology entails the ability to cut intermediaries while still incorporating governance. Thus, the solution must allow for decentralized interactions | Fulfillment | Key requirement EC-Afl03 |
| Technology | DO09: Ensure liquidity through interoperability | The entire infrastructure stack must be fully functional before tokens can be issued and traded on secondary crypto exchanges. The development should comply with the ERC20 standard and state-of-the-art EIPs to ensure interoperability | Interoperability and tradeability | Key requirement EC-Afl02 ICO-Afl01 |

Table 3 (continued)

| Dimension | Design objective | Description | Evaluation criteria | Addressed Afl |
|----------------|--|---|----------------------------------|---|
| Governance | DO10: Align interests by implementing supervision | The prototype must issue funds with a system of checks and balances as an instrument to align the interests of different parties, e.g., voting mechanisms for board-like decisions or vesting periods | Fulfillment | EC-Afl01 ICO-Afl04 ICO-Afl05 ICO-Afl07 |
| Business Logic | DO11: Allow multistage funding | Subsequent tranches and multistage funding allow the alignment of interests via conditional investments and further erase full funding by integrating flexible minting schemes. For multistage funding, the prototype must additionally incorporate common recapitalization mechanisms such as pro-rata | Fulfillment | ICO-Afl01 ICO-Afl05 ICO-Afl07 |
| Technology | DO12: Design the solution with sufficient flexibility | To allow for the individualization of investment contracts in early-stage companies, customization of the contract during the issuance process must be possible. In addition, upgradability features for unforeseeable problems avoid later-stage vulnerabilities | Usage of standards and proposals | ICO-Afl06 ICO-Afl08 |
| Compliance | DO13: Allow escrow and higher interventions | The prototype should allow for third-party operations of accounts and thus specific methods to authorize third parties. While higher intervention is necessary for securities, escrow is a common steering mechanism for special business arrangements | Fulfillment | EC-Afl01 ICO-Afl02 ICO-Afl03 |

Table 3 (continued)

| Dimension | Design objective | Description | Evaluation criteria | Addressed Afl |
|------------|--|--|--------------------------------|------------------------------------|
| Technology | DO 14: Embrace standards and simplicity | Simplicity is vital to reduce the risk of bugs and to facilitate the possibility of future adjustments. Thus, the prototype should use reviewed open-source standards (e.g., ERCs, white papers) and proposals. This enhances interoperability, community interaction and reduces the risk of untested code on the application layer | Use of standards and proposals | EC-Afl01 ICO-Afl06 ICO-Afl08 |

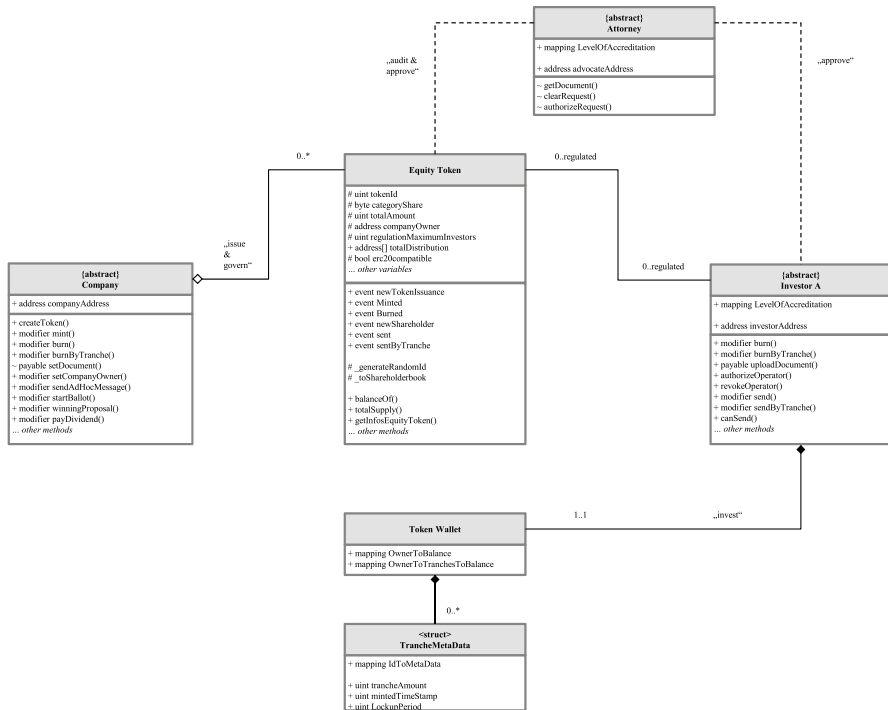


Fig. 3 Class diagram of core building blocks

documents identifying himself (KYC), a necessary process which we will elaborate on in the next section.

5.2 Development and prototype features

Guided by Peffers et al.'s [61] DSR process and the software requirements (DOs), we developed the prototype in iterative steps following a build-and-evaluate process.² For the sake of simplicity, within this paper, we demonstrate three relevant prototype features: the KYC process, the issuing process, and the transaction protocol. We selected these three features as the KYC process is a distinctive feature for equity crowdfunding in contrast to ICOs, and the token issuing process is relevant for crowdfunding in general. The last in-depth feature, token transactions, are a technical core element for transferring value on the blockchain and are of increasing importance owing to the transaction restrictions required for equity token. All further functionality is described in the appendix as well as documented in the open code repository.

² A full version of the implemented prototype and comprehensive documentation of every variable and method is accessible on GitHub (https://github.com/vivowa/solidity_eto.git) after publication.

5.2.1 The know-your-customer process

The KYC process gains center stage for equity crowdfunding: token ownership must be continually tracked in many jurisdictions, and all investors must disclose their identities. Traditionally, to pass a KYC process conducted by a third party such as a bank or an exchange requires a potential investor for identification and final authorization. The KYC principle is crucial to fighting money laundering. Implementing the process requires that investors upload certain documents (e.g., identification documents, proof of residency), which the third party consequently authorizes. To store uploaded documents, we used IPFS, which offers the benefits of blockchain technology and is an efficient way to record documents permanently, securely, and transparently. Uploading encrypted documents with IPFS returns a hash and a key. The investor uploads the document's hash and authorizes a third-party provider. Together with this message, they must send a certain fee to pay for the KYC service. The third-party provider—in our example, an attorney—retrieves the documents, audits them off-chain, and either *authorizeRequest* or rejects the request. In both cases, the *accreditationFee* is automatically transferred to the third party.

After approval, the investor's status code changes to authorized. The protocol consistently ensures that the documents can only be retrieved and encrypted by the authorized attorney. Through IPFS the investors' documents are immutably linked to the blockchain and can be tracked with the investors' address.

5.2.2 Token issuance

At the outset, the issuer creates a token shell that determines key characteristics of the equity token, such as *tokenTicker*, *categoryShare*, and *defaultOperator*. The shell is a template for a customized equity token. Initially, the token's *totalAmount* is zero since the shell is pending, waiting for approval from a third party. For the emission of the token, documents (e.g., annual statement, prospectus) must be uploaded and audited. Again, the request passes a payable on-chain off-chain process similar to the KYC procedure. However, the required documents and audits by the attorney differ and are far more extensive. The attorney audits the shell and classifies the equity. Upon approval, the company can mint multiple rounds of this specific token, depending on its strategy, business model, and investors (see Fig. 4).

5.2.3 Token transaction

Finally, we illustrate a transaction in detail. The transaction protocol is a key feature since equity tokens incorporate several token-level restrictions that ensure compliance with predefined regulations during the entire transaction. Thus, this design prevents accounts from transferring security tokens to unauthorized parties. Figure 5 demonstrates the sequence diagram for a successful transaction.

The issuer allocates the tokens in a primary distribution directly to the investor. Every batch of tokens in the wallet collected and controlled by an owner belongs to a unique tranche. The attached metadata describe each tranche and store information for token-level restrictions, such as a lockup period. For sending tokens, the sender

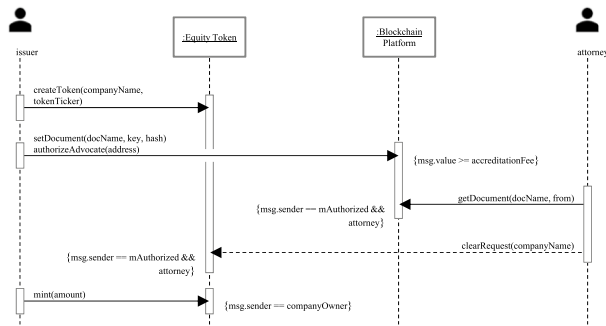


Fig. 4 Sequence diagram for the token issuance

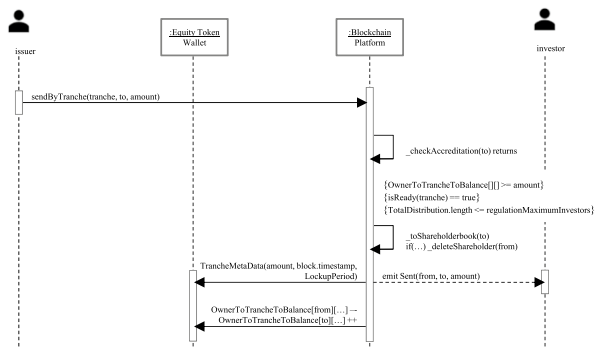


Fig. 5 Sequence diagram for a token transaction

can include a specific tranche for the payment, or a first-in-first-out logic automatically selects a tranche. The sender calls *sendByTranche* and includes the receiver, amount, and tranche. The protocol then checks for both authorization (KYC/AML) and accreditation (e.g., implementing US regulations, where accreditation is conditional on the receiver's wealth) of the receiver. After the first successful check, the protocol controls whether the sender's balance is equal to or larger than the sending amount. Further, the protocol accesses both the *trancheMetadata* and general information of the token.

While the tranche's metadata is necessary to check whether the lockup period has expired since the last trade, further general information allows one to check for regulatory restrictions. In our prototype, we restricted the maximum number of investors per company. The transaction protocol enlarges the public record of ownership and deletes an owner if their stake in the company is zero after a successful transaction. The receiver's wallet receives the token if all checks pass and calculates the new balance of both sender and receiver. In the receiver's wallet, the tokens build a new tranche that gets new specific *trancheMetadata*. As a final step, the blockchain broadcasts a successful transaction event to the network. All transactions are atomic.

If only one check is unsuccessful, the blockchain will perform a rollback to the original state. A transaction can also generally be executed by an authorized operator. Only the token owner can *authorizeOperator* and *revokeOperator*, which function as trustees to manage a portfolio. By default, a governmental address is also an authorized operator. The possibility of intervention is one mechanism to prevent fraud or crime and is a key design objective.

6 Evaluation

Following DSR, thoughtful evaluation of the proposed design artifact is a key request [28]. The proposed design artifact should demonstrate utility, quality, and efficacy. That is, the artifact solved the intended purpose [67]. The prototype has been fully implemented and deployed on an Ethereum test network, satisfying the core utilities in a testing environment. We proceed with a comprehensive evaluation in two steps to gauge the efficacy; each step broadened the evaluation's scope [67]. As Gregor and Hevner [27] proposed, we foremost strove for a comparative assessment, analyzing whether equity tokens are beneficial compared to the previous blockchain solution (efficacy). Thus, we applied a criteria-based evaluation and compared the prototype to the addressed Afls. Finally, we presented our research approach and prototype to industry experts in seven semi-structured interviews to evaluate the quality and derive more general insights.

6.1 Criteria-based evaluation

We presented our prototype to the derived Afls and assessed whether the implementation of our DOs showed that an equity token improved the existing solution (see Table 4).

In sum, many DOs seek to enhance trust and reduce adverse selection impacts by dismantling the asymmetrical information between interacting parties, aligning interests, and minimizing the regulatory uncertainty about an equity token. Equity tokens reduce the overall transaction costs of early-stage funding. Decentralization is a fundamental benefit of blockchain, reducing the middlemen and expenses required to conduct transactions on the Ethereum blockchain.³ In general, we propose that token funding changes the market's perspective: traditionally, funding-seekers must discuss funding terms with every single potential investor. Using equity token improves efficiency since the issuers' terms are broadcasted worldwide via the blockchain and accompanied by real-time settlement. Overall, the implemented DOs reduced transaction costs for purchasing and trading in equity and technically granted access to investors type globally.

Furthermore, small investments become economically viable owing to lower transaction costs. Token-level restrictions and investor identification ensure high

³ The test scenarios yielded average computational costs of 821,000 gas for creating and minting tokens (without one-time KYC/AML), at more than 20 transactions per second [26].

Table 4 Criteria-based evaluation of AftIs and DOs

| Area for improvement | Targeted DOs | Evaluation of prototype |
|---|--------------|---|
| EC-Aft01: Credibility of crowdfunding platforms | DO04 | Currently, the services of platform providers conduct equity crowdfunding and thus require a significant level of trust. Given the trustless nature of Blockchain [35], participating parties can use equity crowdfunding without relying on a central intermediary |
| | DO05 | |
| | DO13 | |
| | DO14 | |
| EC-Aft02: Missing secondary market | DO03 | In contrast to many traditional equity crowdfunding platforms, the developed equity token enables trading on secondary markets. The prototype is based on the ERC20 interface standard and supports functions for transferring tokens to other market participants [65, 81]. The interoperability of the equity token with existing crypto exchanges and other services and existing wallets is easily realizable [81] |
| | DO07 | |
| | DO09 | |
| EC-Aft03: High administration/ transaction costs | DO06 | The artifact supports the digitization of the equity crowdfunding process using the equity tokens as digital financial contracts. Building on IPFS allows distributing digital documents among the required stakeholders efficiently [82]. Therefore, especially KYC and AML related processes could become more streamlined [83] |
| | DO89 | |
| ICO-Aft01: Price discovery | DO01 | Currently, market mechanisms drive the volatility of tokens rather than specific token designs [15]. However, equity should become easier to price with increased market maturity, as traditional valuation models are applicable. The prototype considers the key characteristics of equity, supports the management of investor relationships during the equity's lifecycle, and ensures regulation enforcement |
| | DO02 | |
| | DO09 | |
| | DO11 | |
| ICO-Aft02: Not compliant with current regulation | DO01 | Equity tokens generally improve investor protection since the issuance comes with legal obligations for the issuing companies. Through the programmability of equity tokens, regulatory requirements can be efficiently enforced ex-ante the transaction, saving the need to audit afterward. The prototype incorporates token-level restrictions (KYC/AML, accreditation) and provides a seamless process for investor identification. The ownership of every equity token can be continually tracked owing to partial fungibility. The prototypes offer various mechanisms to align investors' and funding seekers' interests, such as voting, vesting, multistage funding, and escrow services |
| | DO02 | |
| | DO05 | |
| | DO13 | |
| ICO-Aft03: Incompatible with higher interventions | DO13 | We implement the possibility of access by a third-party operator into the equity token prototype. This optional mechanism enables higher interventions in instances of fraud or unauthorized ownership. Our prototype also allows for the authorizing and revoking of operators |

Table 4 (continued)

| Area for improvement | Targeted DOs | Evaluation of prototype |
|--|------------------------------|--|
| ICO-AFI04: No reporting standards | DO01 DO04 DO05 DO12 | Our prototype enables ad hoc messages by the issuing company but does not enforce it regularly with oracles. Nonetheless, we argue that it should be discussed whether communication must be stored on-chain or can be managed off-chain |
| ICO-AFI05: Conflict with the equity funding cycle | DO12 DO13 DO13 | Through increased rights and obligations, equity tokens provide a higher level of alignment. Equity tokens can be used to financially incentivize through tranches, different equity token types, as well as multiple batches of one type, can be issued conditionally on specific milestones |
| ICO-AFI06: Inflexible architecture | DO12 DO14 | The prototype implements a proxy logic to swap smart contracts in case of updates. However, this is not optimal as smart contracts' upgradability on a blockchain is a general problem [89], providing future research opportunities |
| ICO-AFI07: Limited configurability | DO10 DO11 | Through programmability, equity tokens offer an infinite design space for securities' financial engineering and technical implementation [35] |
| ICO-AFI08: Risks in the ICO code | DO12 DO14 | Most utility tokens follow the same token standard (i.e., ERC20). This standard can also be applied to equity tokens. On the other hand, the increased complexity of equity tokens increases the risk of malicious code. Our prototype incorporates state-of-the-art proposals (e.g., ERC20, ERC777, EIP1400) and thus also helps to standardize equity tokens |

Table 5 Overview of the interviewees

| Expert ID | Professional title | Field of expertise | Organization type | Relevant experience |
|-----------|--------------------|-----------------------------------|----------------------|---------------------|
| EXP1 | COO/Entrepreneur | Blockchain/Early-stage funding | Research institute | > 8y |
| EXP2 | Fund Manager | Early-stage funding, crowdfunding | Investment bank | > 3y |
| EXP3 | COO/Consultant | IT platform, Blockchain | Crypto exchange | > 5y |
| EXP4 | Research Assistant | Blockchain | Research institute | > 3y |
| EXP5 | Senior Consultant | Technology transformation | IT Consultancy | > 5y |
| EXP6 | Business Developer | Blockchain | Blockchain community | > 3y |
| EXP7 | Head of Sales | Blockchain, crowdfunding | Blockchain fintech | > 8y |

compliance levels and thus secure the underlying value of a security on the blockchains. Overall, the transparency increases since each update of the equity token's implementation include a timestamp recorded on the blockchain and stores key documents publicly.

6.2 Semi-structured interviews

We conducted seven semi-structured interviews with industry experts to evaluate our prototype for quality and derive generalized design principles for equity token. For our research approach, semi-structured interviews are a natural fit since they are a flexible evaluation technique. On the one hand, the interviewer sets up a general interview structure and covers the main questions, deciding in advance on the direction to be covered; on the other hand, the interviewee has a fair degree of freedom on how to answer and to what extent [68, 69]. We reached out to potential interview partners from the authors' network. In general, we aimed to gather a heterogeneous interview panel, including academics, practitioners, and technical or business experts. In total, we conducted two rounds of interviews: starting with three interviewees and adding four more experts in the second iteration (reducing interviewees' time commitment). The interviews took place at the end of 2020, and the participants are listed in Table 5.

Beforehand, all the interviewees received a summary presentation about the research approach, the underlying problem domain, and crucial working definitions to foster open discussion and maximize the output. In the structured part of the interviews, we discussed the lists of Afls and DOs. The interviewees assessed the Afls and DOs according to agreement, performance, prioritization, and completeness. We included the results of this feedback directly into our design artifact, utilizing the iterative nature of our research approach (see Fig. 6), which has proven beneficial multiple times in IS research [60, 61]. The semi-structured part of the interview consisted of a set of open questions to allow for open discussion of all aspects. The twelve questions have been created in multiple workshops among the author team. Questions included the advantages and disadvantages of blockchain-based tokens

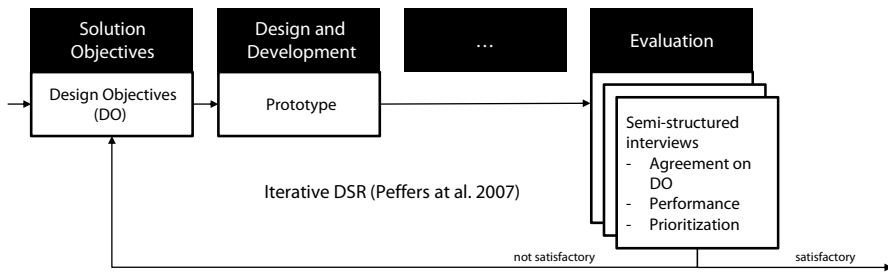


Fig. 6 Iterative design, development, and evaluation of the artifact (based on Peffers et al. [61])

for equity crowdfunding, the value-add of blockchain technology within the crowdfunding process, and the technology's maturity and biggest remaining hurdles. We sought to achieve a more general understanding of blockchain-based equity crowdfunding, facilitating a higher abstraction level and deriving more general applicable knowledge. We recorded the interviews and used qualitative techniques, such as the transcription and coding of the interviews. Later, the authors discussed the results of the analysis until a common understanding was reached.

All interviewees emphasized that blockchain technology can play a crucial role in early-stage equity funding if the funding seekers' applicability becomes more convenient and fully exploits blockchain technology's benefits. In addition, the interviewees agreed that the following key attributes exploit tokenization's potential fully: increased liquidity, divisibility, reduced friction, disintermediation, removed geographical barriers, and more transparency. Interestingly, every expert acknowledged that the Ethereum blockchain provides a matured infrastructure for developing equity tokens. EXP7 stated that this is particularly true since Ethereum enables the implementation of smart contracts, has a larger development community, features more robust IT security, and allows for the compatibility of token standards. Concerning privacy, EXP4 agreed to use Ethereum and recommended considering a permissioned blockchain such as Hyperledger Fabric since it provides built-in privacy features. To address the prototype's applicability, they called for reducing the technical entry barriers of equity tokens through a customer-friendly user experience and further standardization of protocols. The interviewees mentioned unclear and fragmented regulations as one primary challenge to exploiting the full potential of equity tokens calling for a clean regulatory environment without limiting the innovation in this space.

Concerning the transformation from ICOs to equity tokens, all are seeing a considerable improvement compared to the first wave of blockchain funding and agreed to strict definitions determined by the token characteristics. All the interviewees valued improved investor protection, token-level regulations, and the underlying value of security tokens. In this context, EXP2 stated that volatility and speculation owing to immature valuation was also a phenomenon in equity during the Dot-Com bubble. But with a maturing market, the valuation methods and experience improved.

Regarding ICOs, EXP3 stated that the financial success was faster than the technology's maturity and emphasized that ICOs addressed "retail investors without

time or an interest in doing due diligence.” While the public has pushed ICOs, he expects that the established industry’s equity tokens will value more rationally. Indeed, EXP3 called it a “desirable development” since “retail investors should not be in that space.”

Market liquidity for equity tokens was another key discussion with all the interviewees. EXP7 supported stated that tokenization is especially useful when considering asset classes with low trading volumes as large assets are already trading efficiently. In this context, EXP6 said that tokenization “makes dead capital” (i.e., illiquid asset classes, such as crowdfunding) more liquid, and allows for fractional ownership, ultimately granting access to a broader investor base.

Also, the regulation of equity tokens was a controversial topic among the interviewees. While they all agreed that a certain level of regulation is necessary for equity tokens, the optimal level of regulation they proposed was diverse. EXP4 noted that, in this context, it is crucial to grant access to various participants, such as tax authorities, brokers, exchanges, and other financial services, and to set standards that are supported by public authorities. Such an approach could also include the use of master keys, allowing for the freezing of assets. EXP6, on the other hand, denied the meaningfulness of allowing central entities to take corrective actions: “this would counteract the whole idea of blockchain, making a decentralized system central again.” EXP5 eventually pointed out that regulating equity tokens is a mixed bag. While handling AML requires master keys, over-regulation can lead to tokens losing their benefits compared to conventional systems.

Following EXP5, technical standards are strictly required to allow for the mass adoption of equity tokens. Remarkably, the ERC20 demonstrates the effect of agreeing on a specific standard, facilitating a substantial number of ICOs. Further, standards are necessary to integrate third parties, such as exchanges. This interviewee emphasized the nascent status quo and called for further development in this field.

7 Discussion

Our design has introduced an approach for automated, secure, and customized issuance of an equity token on the Ethereum blockchain, aiming to provide a novel approach for equity crowdfunding. Thus, we contribute to the body of knowledge on the developing blockchain-based equity crowdfunding domain [9, 12, 23, 24, 58].

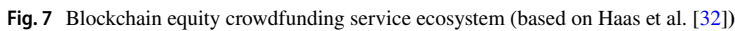
The literature on equity crowdfunding points out that investors only have limited exit options, leading to higher risks and despair [12, 70, 71]. Conversely, our system allows an early-stage company to create and distribute their shares on a primary issuance platform and facilitates interfaces to exchanges for secondary market trading. In addition, investor relationships can be managed by the issuing company on-chain throughout equity lifecycle applications. Since every successful transaction of tokens is automatically recorded, the system provides a complete and tamper-proof transaction history and distribution of the equity token ownership. The system operates without institutional involvement through decentralized protocols and complies with a predefined regulatory framework, owing to self-regulating tokens. We find that by using an instance of a blockchain-based equity token for crowdfunding, the

advantages of tokenizing equity can be realized, as demonstrated with our prototype, and therefore agree with Chen [6] and Roth et al. [14].

From a technological perspective, applying blockchain technology in the equity domain constitutes multiple benefits. First, due to decentralized protocols, trusted institutional intermediaries are not necessary to manage the system infrastructure like accounts and transactions, thereby largely reducing friction [72]. Not a single participant in the system needs to be trusted because the inherent consensus mechanism of blockchains ensures the network's administration and follows smart contracts' logic. Inadequate use is still possible but is lowered to a minimum since the deployed algorithms govern human behavior [12, 26]. Second, blockchains' decentralized structure allows us to store all the relevant data on the network's nodes [73]. Thus, our prototype enhanced general reporting and auditability since the nodes store all relevant data transparently and allow regulatory entities or third-party providers to retrieve them easily. Due to its high level of redundancy, the system becomes resilient against potential cyberattacks and prevents single points of failure [26]. The inherent security features of our equity token reduce the trust barrier in crowdfunding, which remained a major concern in traditional, centralized equity crowdfunding [12]. Overall, our system works like a transparency device that assures the availability of a complete, valid, and public record of both historical and present equity ownership, thereby encrypting and attaching key documents (e.g., KYC) [87, 88]. Third, the prototype significantly reduces transaction processing time since blockchain uniquely combines the recording and value transaction. Traditional equity crowdfunding suffers from cumbersome administration processes. These include paper-based documentation and global distribution by mail, which dramatically slows down the transfer of ownership and thus increases dependencies on intermediaries [13, 70]. Our equity token clears initial transactions in seconds, thus fostering the rapid exchange of ownership.

Overall, our understanding of blockchain-based equity crowdfunding differs from traditional equity crowdfunding. Thus, we extend the traditional crowdfunding model proposed by Haas et al. [32] by redesigning the service ecosystem holistically through the introduction of blockchain in the context of equity crowdfunding. Our model extension reveals the elimination of payment providers and banks through blockchain, which now covers all services provided by the former intermediaries (see Fig. 7). To consider the regulatory requirements of equity crowdfunding, we also include attorneys, regulatory authorities, and external auditors as vital stakeholders within the system. We correspondingly note that our model also differs from the one proposed by Schweizer et al. [56]. While there are differences, as Schweizer et al. [56] describe their model in the context of crowdlending, we disagree with the general conception that blockchain entirely cuts out intermediaries and all tasks can be outsourced. In essence, their model shows that smart contracts can be responsible for all services provided by the crowdfunding partner, including crowd activation and customer support.

Although it is theoretically possible to outsource these tasks to very complex smart contracts, we still see the crowdfunding partner as an essential stakeholder to provide the mentioned services. Similar to exchanges providing services on top of ICO tokens, we propose that crowdfunding partners offer services on top of equity



Design science should provide archival knowledge [28], and, thus, contributing to design theory is a vital part of conducting DSR [27]. Following Beck et al. [26], we propose design principles (see Table 6) to contribute to the body of knowledge on designing blockchain-based systems [26, 27]. Due to extensive prototyping, rigorous evaluation, and semi-structured interviews, we generalize our findings and thus argue applying equity tokens beyond the equity crowdfunding domain. Accordingly, they could act as comprehensible guidelines for the effective design of equity tokens.

Off-chain physical documents are often needed to assess a claim of ownership. Notably, progressive jurisdictions are moving forward to replace physical documents with digital ones. To minimize the data necessary to be stored on a blockchain (and thus costs), we advise storing a pointer (i.e., hash) toward a set of documents instead of storing the documents. In particular, distributed systems such as IPFS can build a suitable balance between complete centralization of legacy systems and highly decentralized public blockchains.

Every equity token should include metadata. Thus, equity tokens can become fungible. Metadata is a pre-requirement to set up very granular transaction conditions, which can be asserted with every transaction. Incorporating transaction requirements in smart contracts allows checking requirements before a transaction is executed. This assertion renders post-transaction audits completely obsolete.

Table 6 Design principles for blockchain-based equity tokens

| Design principles | | Addressed AfIs |
|-------------------|---|--|
| DP1 | Lever a combination of blockchain and other distributed technologies | EC-AfI01, EC-AfI03, ICO-AfI02, ICO-AfI04 |
| DP2 | Lever token metadata to include granular transaction requirements | ICO-AfI01, ICO-AfI02, ICO-AfI07 |
| DP3 | Follow token standards and standard interfaces to increase interoperability | EC-AfI01, EC-AfI02, EC-AfI03, ICO-AfI02, ICO-AfI04, ICO-AfI08, |
| DP4 | Central administration should only be incorporated as a last resort | EC-AfI01, ICO-AfI02, ICO-AfI03, ICO-AfI08 |
| DP5 | Allow for multiple tranches over the token life cycle | EC-AfI02, ICO-AfI01, ICO-AfI02, ICO-AfI05, ICO-AfI07 |
| DP6 | Use a public blockchain to facilitate transparency | EC-AfI01, ICO-AfI04, ICO-AfI08, |
| DP7 | Give power to the machine | EC-AfI01, ICO-AfI03, ICO-AfI04, ICO-AfI06, ICO-AfI08 |

Typical examples are the accreditation status, the token creation date, or the emitting jurisdiction.

DP3: Follow token standards and standard interfaces to increase interoperability

The blockchain, a single infrastructure layer, powers crypto tokens. In applying the same standards to the token, these assets can interact with one another. Standards can be established by open-source communities, corporate alliances, and academia or can be determined by governments. For instance, in our Ethereum prototype, ERC20 (token standard) and EIP1400 (security token standard) received significant community support. Interoperability eventually increases the entire ecosystem's efficiency. Additionally, open standards reduce the chances for security flaws through peer code reviews.

DP4: Central administration should only be incorporated as a last resort

The reason for central administration is manifold. Regulation (e.g., AML) and security flaws (e.g., as it happened with the DAO hack) require centralized entities to intervene. As such, we implemented options to register public keys, which allows the owner to pause tokens. While we acknowledge the necessity for such centralized administration, we still consider it a last resort method since it directly goes against a vital feature of a blockchain—decentralization.

DP5: Allow for multiple tranches over the token life cycle

The practice of attaching metadata to equity tokens and technically structuring the tokens according to their metadata, i.e., tranching, is beneficial to allow very granular token transaction requirements (see DP2) and supports the issuance of differently designed equity tokens over the lifecycle of a company. As early-stage companies are dynamic and have multiple funding rounds, each round could be represented by a new tranche of equity tokens.

DP6: Use a public blockchain to facilitate transparency

Public blockchain technology is inherently transparent as it stores transactions publicly and immutably on a distributed register. By design, this transparency results in the public recording of all equity token transactions. The companies' equity management, such as dividend payments or issuance of new tokens, is stored throughout the lifecycle. This implementation potentially decreases the burden on reporting and auditing of the company.

DP7: Give power to the machine

Smart contracts allow the automation of arbitrary business logic securely. Therefore, we promote their use to automate recurring tasks of equity tokens. For example, in the prototype, we used sophisticated transaction restriction assertions: It is technically infeasible to send the equity token to a non-compliant receiver. Outsourcing automation to smart contracts potentially increases efficiency as well as system robustness. Thorough one-time audits ensure that smart contracts are always executed correctly.

We position our research to fill the gap in the IS literature on the design theory of blockchain-based equity tokens. We used a rigorous DSR approach to the design, development, and evaluation of a blockchain-based equity token prototype for crowdfunding [27, 61]. Thus, we answer our research questions on how blockchain can be incorporated as an alternative infrastructure for equity crowdfunding.

In addition, we extended an established crowdfunding model and developed seven principles for the effective design of equity token. Overall, we embedded our theoretical insights in the current academic discourse, thereby following the calls by Treiblmaier et al. [30], Kranz et al. [22], and Perdana et al. [31] to contribute to the design theory on blockchain tokens.

8 Conclusion

The developed blockchain prototype sought to offer new insights into the design of equity tokens. We designed an instance solution toward the problem areas of equity crowdfunding and ICOs, developing an equity token that covers the entire equity lifecycle. We derived general knowledge that is eventually applicable to blockchain-based equity beyond equity crowdfunding through the development, evaluation, and expert interviews.

We sought to make several contributions to the body of knowledge. First, by focusing on a specific form of company funding and presenting the solution design, we provided an answer to effectively tokenizing equity for crowdfunding. Second, the research process helped us better understand whether a particular type of crowdfunding could benefit from the characteristics of blockchain. Third, we provided an extended model for the blockchain-based equity crowdfunding service ecosystem. Fourth, we derived generalized design principles to guide the design and development of blockchain-based equity tokens.

In addition, our research offered various practical implications. First, early stage companies can use the source code of our prototype to build an equity token to fund their business, thus, improving the funding process holistically. Second, we showed that certain third parties will still play an essential role in the early-stage funding ecosystem regarding the complex regulatory requirements. Third, the prototype demonstrated how using the token ecosystem could increase the liquidity of equity shares and encourage secondary market trading, opening the equity market to new investors.

Also, this study had limitations. We used the Ethereum blockchain as an instantiation reference. However, public blockchains could function as an infrastructure with improved privacy features and performance. Although we have provided an instantiation example, our design principles required additional validation with qualitative interviews backing our findings. We, therefore, call for future research into understanding the relationships between company funding and the benefits equity can gain from being tokenized. In addition, future design-oriented research could apply our design principles in different contexts, e.g., private equity or venture capital, and can thus assess their general applicability.

Equity token will establish their places in the blockchain ecosystem considering the rapid development and increased interest in the equity token ecosystem. In the following years, we expect that many equity tokens will enter the market. From a technological perspective, equity tokens have substantial potential to improve legacy financial infrastructures vastly. From a business perspective, equity token will facilitate the funding process.

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Authors and Affiliations

Tobias Guggenberger^{1,2,3} · Benjamin Schellinger^{1,2,3}  · Victor von Wachter⁴ · Nils Urbach^{1,2,5}

Tobias Guggenberger
tobias.guggenberger@fim-rc.de

Victor von Wachter
victor.vonwachter@di.ku.dk

Nils Urbach
nils.urbach@fim-rc.de

- ¹ Branch Business & Information Systems Engineering of the Fraunhofer FIT, Wittelsbacherring 10, 95444 Bayreuth, Germany
- ² FIM Research Center, Wittelsbacherring 10, 95444 Bayreuth, Germany
- ³ University of Bayreuth, Universitätsstraße 30, 95447 Bayreuth, Germany
- ⁴ Department of Computer Science, Faculty of Science, University of Copenhagen, Universitetsparken 1, 2100 Copenhagen, Denmark
- ⁵ Frankfurt University of Applied Sciences, Nibelungenplatz 1, 60318 Frankfurt am Main, Germany